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# Output-Based Regulation: Best Practices for Regulators

**National CHP Turbine Technology and Regulatory Forum**

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*Prepared under contract for EPA*

# Overview

- Project scope and purpose
- What is output-based regulation?
- Why apply output-based regulation?
- How to implement output-based regulation?
- Case studies
- Who has implemented output-based regulation?
- Next steps

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# Output-Based Regulation: Best Practices for Regulators

- Project of EPA's CHP Partnership
- Purpose: Support air regulators seeking to encourage energy efficiency as a control strategy.
- Products:
  - White paper: Nuts and bolts -- What, why and how
  - Outreach and support to air regulators

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# What is Output-Based Regulation?

- Regulation that relates emissions to the productive output of a device or process.
  - Unit of emissions/unit of output
  - lb emission/MWh
- Can be applied for any process
  - Our focus is the power/large boiler sector

# Measurement in Air Regulations

- Historically based on industry practice.
- Some regulations have always been output-based:
  - Engines - g/bhp-hr
  - Industrial processes - lb emission/ton of product
  - Cars - g/mi

# Power Generation and Boiler Regulation Have Not Been Output-Based

- Boilers - $lb/MMBtu_{in}$
- Turbines - ppm
- Eliminate energy efficiency as a control option.

*Output-based version is:*

*$lb/MWh_{out}$*

*$lb/MMBtu_{out}$*

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# Why Output-Based Regulation?

- Recognizes and rewards efficiency which translates to:
  - Reduced fuel consumption (multimedia and energy security impacts)
  - Multi-emission reductions
- Provides a common basis for comparison - apples to apples.
- Relates cost (pollution) to benefit (productive output).

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# Evolution of Air Quality Regulation

- Initial focus was add-on/end of pipe controls to reduce existing pollution.
  - Great progress has been made on air quality.
- Pollution prevention (P2) is an additional tool to enable further, cost-effective progress.
  - Improving efficiency in any process is P2 at its best.
- Output-based regulations promote efficiency.

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# Efficiency as a Pollution Control Measure

- Reduces all emissions, including non-regulated and greenhouse gases.
- It's always "on". No start-up, shut-down or malfunction interruptions.
- Provides additional options for emission reduction.
- Makes emission reduction more cost-effective.

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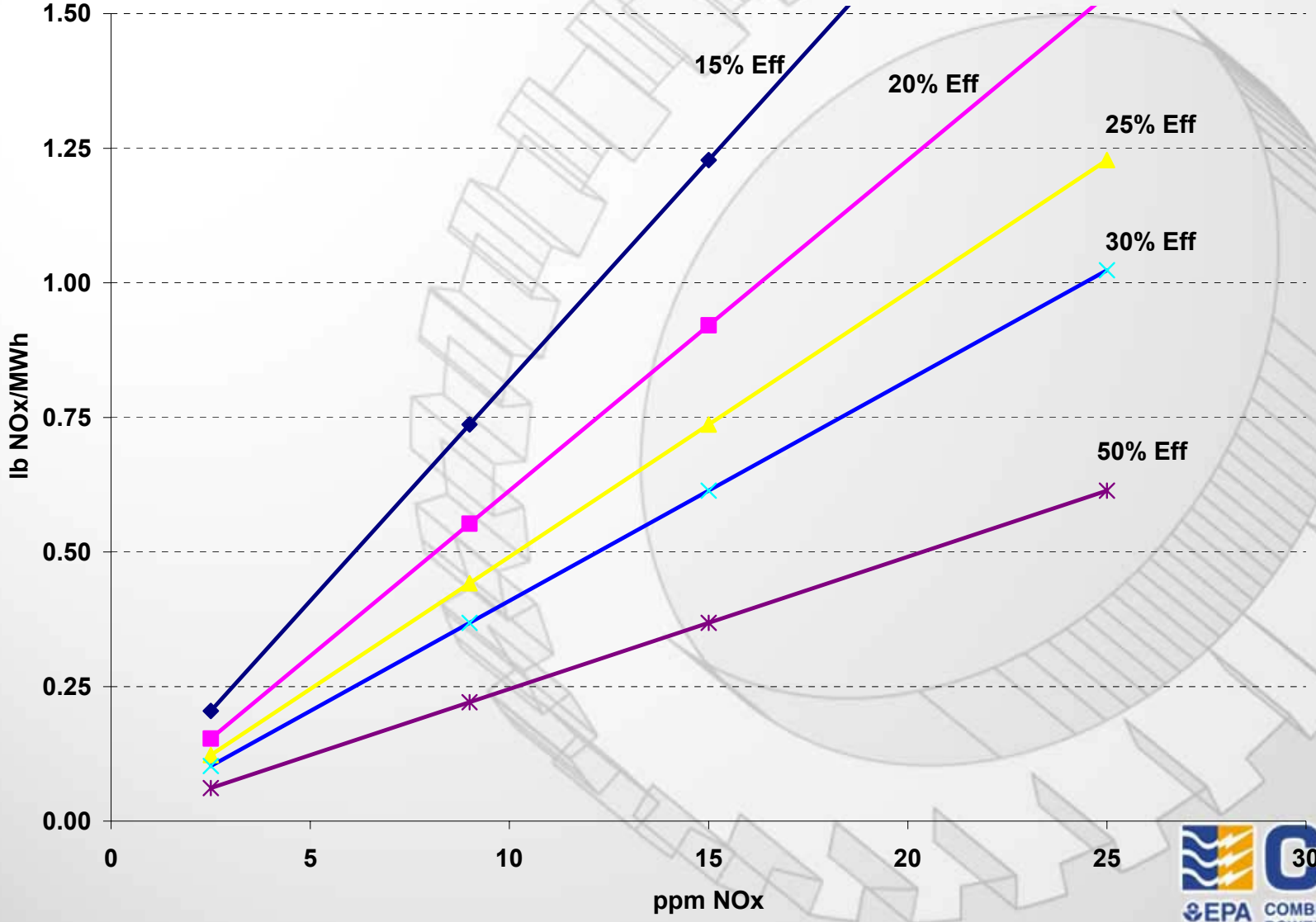
# Design Flexibility Benefits

- Incorporating efficiency allows alternatives to add-on pollution control.

| Plant efficiency (percent) | Control device efficiency (percent) | Emission limit lb/MWh |
|---|---|---|
| 34 | 60 | 1.3 |
| 40 | 50 | 1.3 |

# Efficiency Effect on ppm Emissions

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# Applications of Output-Based Regulation

- Conventional emission rate regulations
- New rules for smaller generators
- State and Federal multipollutant programs
- Generation performance standards
- Allowance allocation in trading programs

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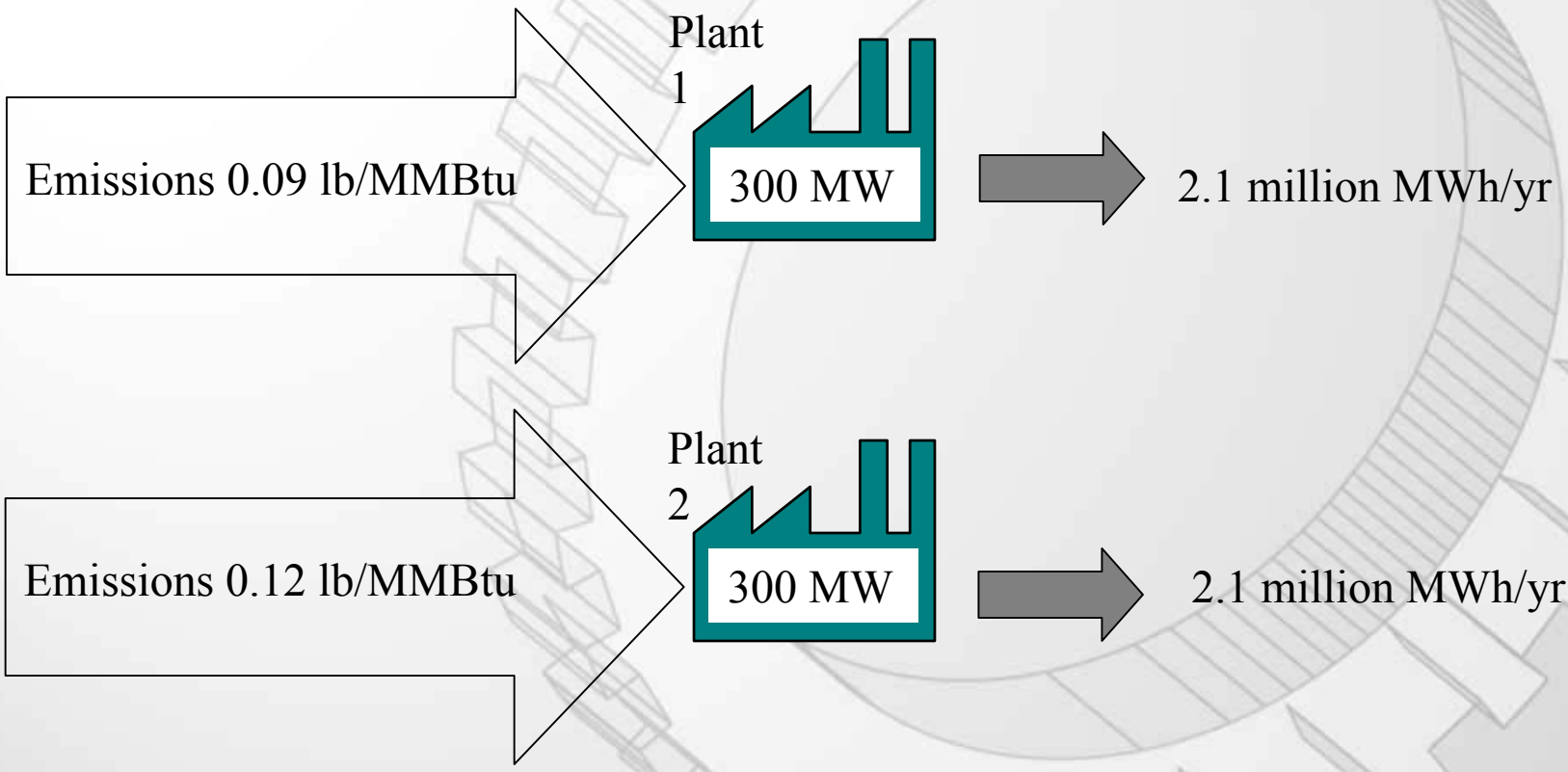
# Conventional Rate Limits

- Output-based regulation allows and encourages efficiency to be used as a control option.
  - Combustion efficiency
  - Reduced parasitic loads
  - Generator efficiency
- Links emissions to productive output.

# Benefits of Output-Based Regulation

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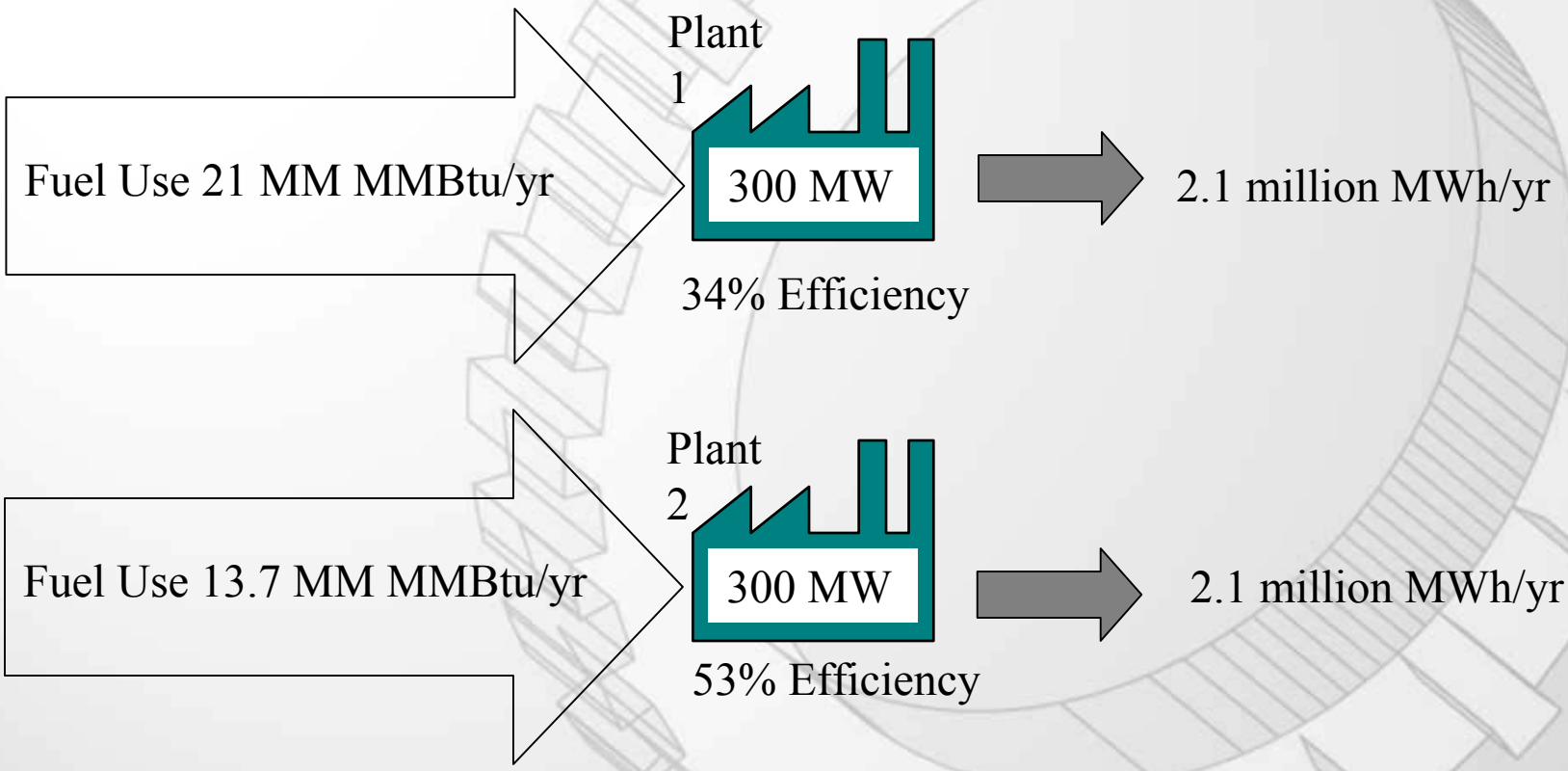
# Benefits of Output-Based Regulation

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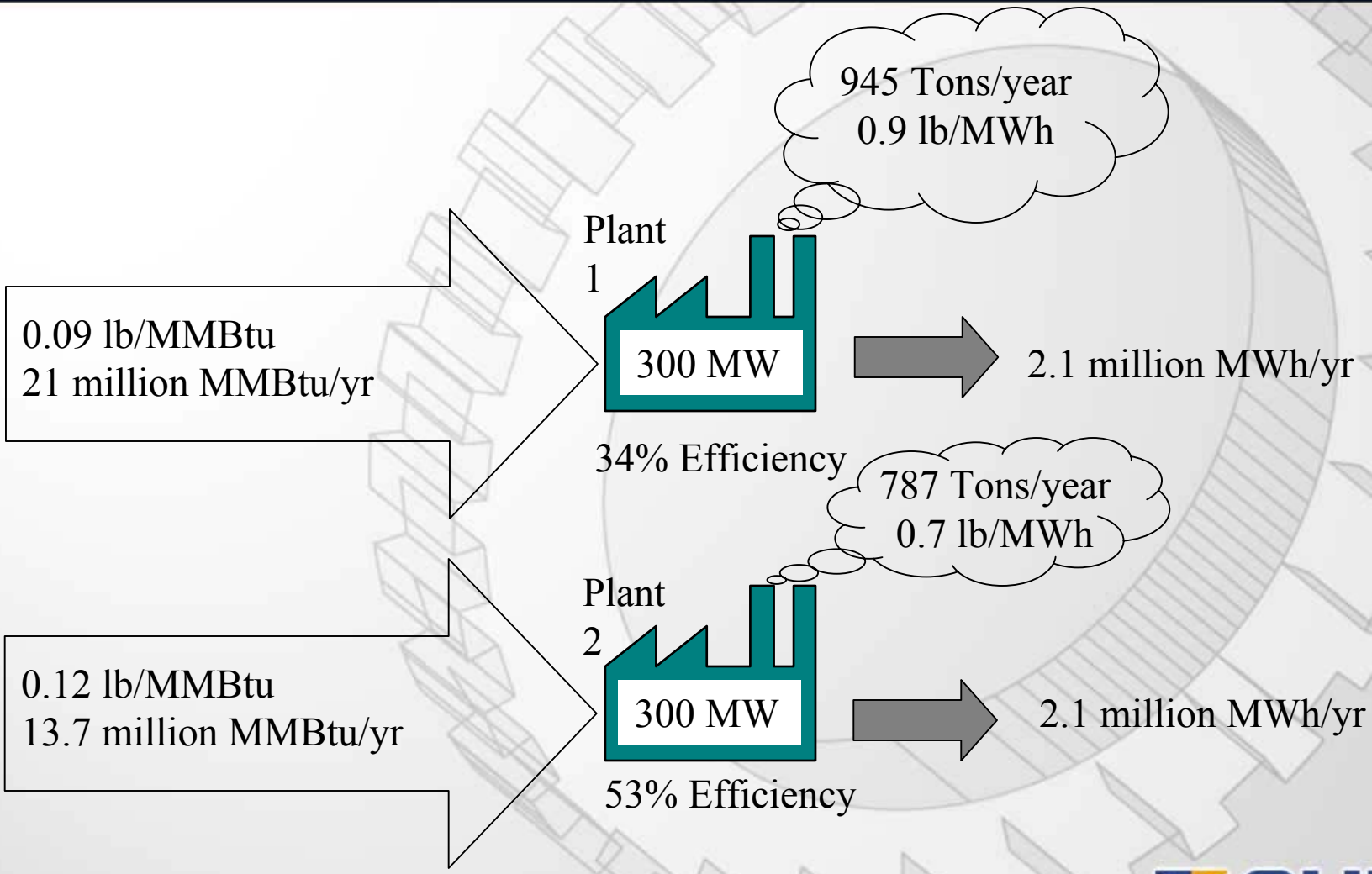
# Benefits of Output-Based Regulation

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# Allowance Allocation

- Allowance allocation is a critical component of cap and trade programs.
- Input-based allocation rewards inefficiency.
- Output-based allocation rewards efficiency and encourages clean technology.

# Input vs Output-Based Allocation

| Basis of Allocation | Plant 1 | Plant 2 |
|---|---|---|
| Heat Input | | |
| Heat Input (MMMMBtu/yr) | 21.0 | 13.7 |
| Percent of Total Heat Input | 61% | 39% |
| Allowances Allocated | 909 | 591 |
| Implied Emission Reduction | 4% | 25% |
| | | |
| Energy Output | | |
| Output (MMMWh/yr) | 2.10 | 2.10 |
| Percent of Total Generation | 50% | 50% |
| Allowances Allocated | 750 | 750 |
| Implied Emission Reduction | 21% | 5% |

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# Example: CHP

Combined Heat and Power is the generation of electricity and heat sequentially from the same heat input.

- Electricity primarily used on-site, but some can be sold back to grid. Grid can serve as back-up or swing provider.
- Thermal energy used for heating/cooling or process applications.

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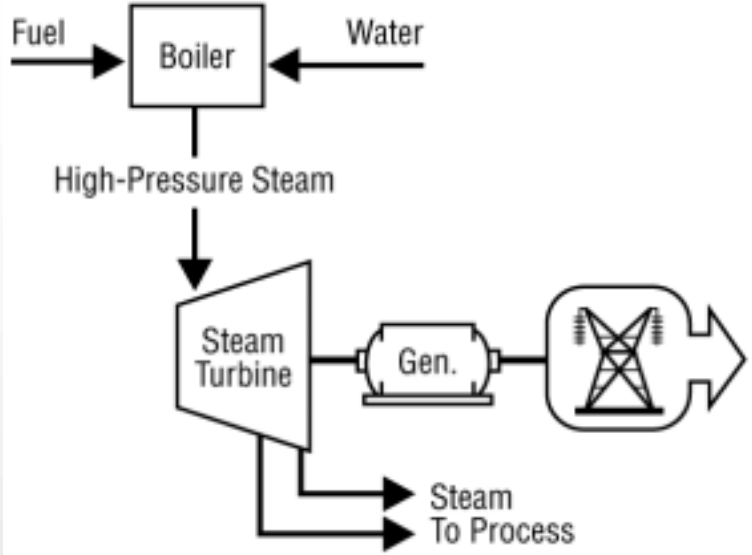
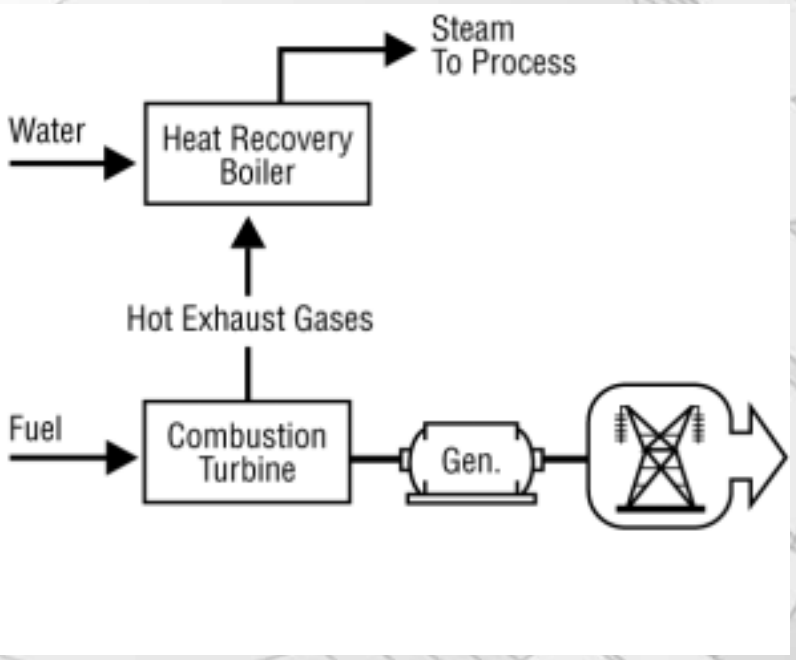
# Typical CHP Systems

**Steam Boiler/Steam Turbine:**




**Gas Turbine or Engine/Heat Recovery Unit:**

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# Advantages of CHP

- CHP is *more efficient* than separate generation of electricity and heat.
- Higher efficiency translates to *lower cost*.
- *Use of waste or byproduct fuel*, where available, further reduces cost.
- On-site electric generation *avoids distribution costs,* a significant component of grid electricity price.
- *Increased reliability and power quality* can also add significant value.

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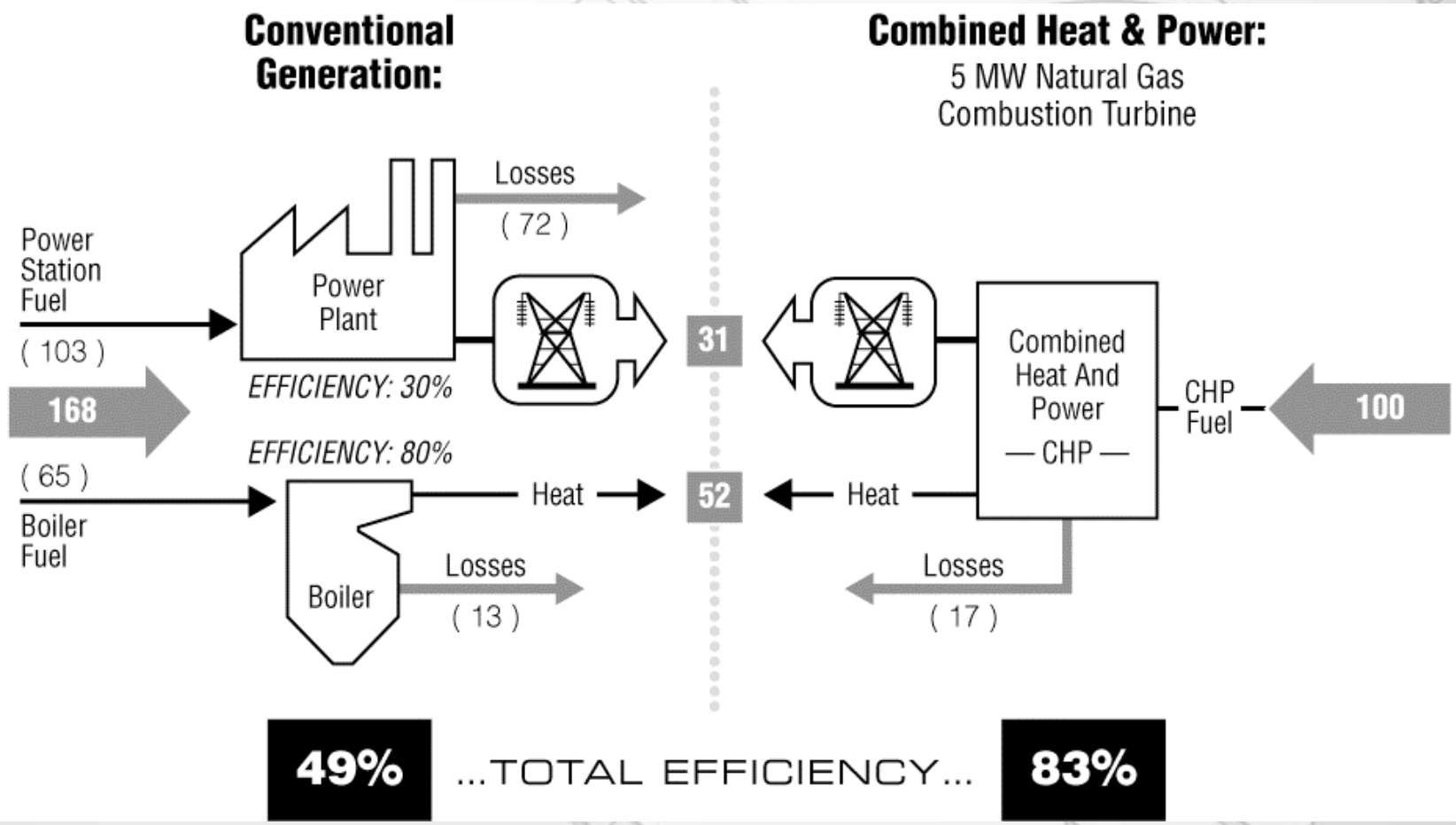
# Efficiency Benefits of CHP

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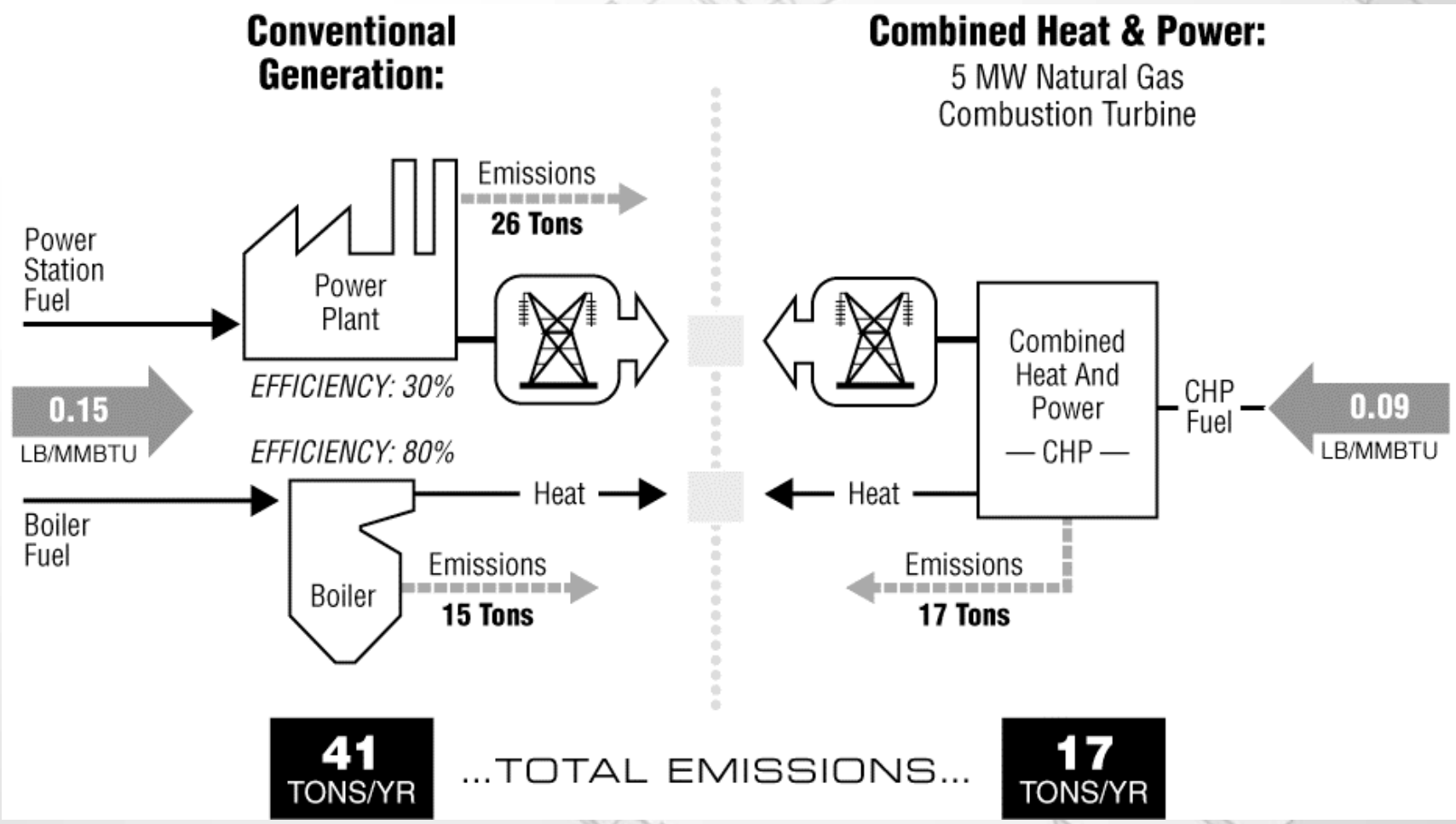
# Environmental Benefits of CHP ($NO_x$)

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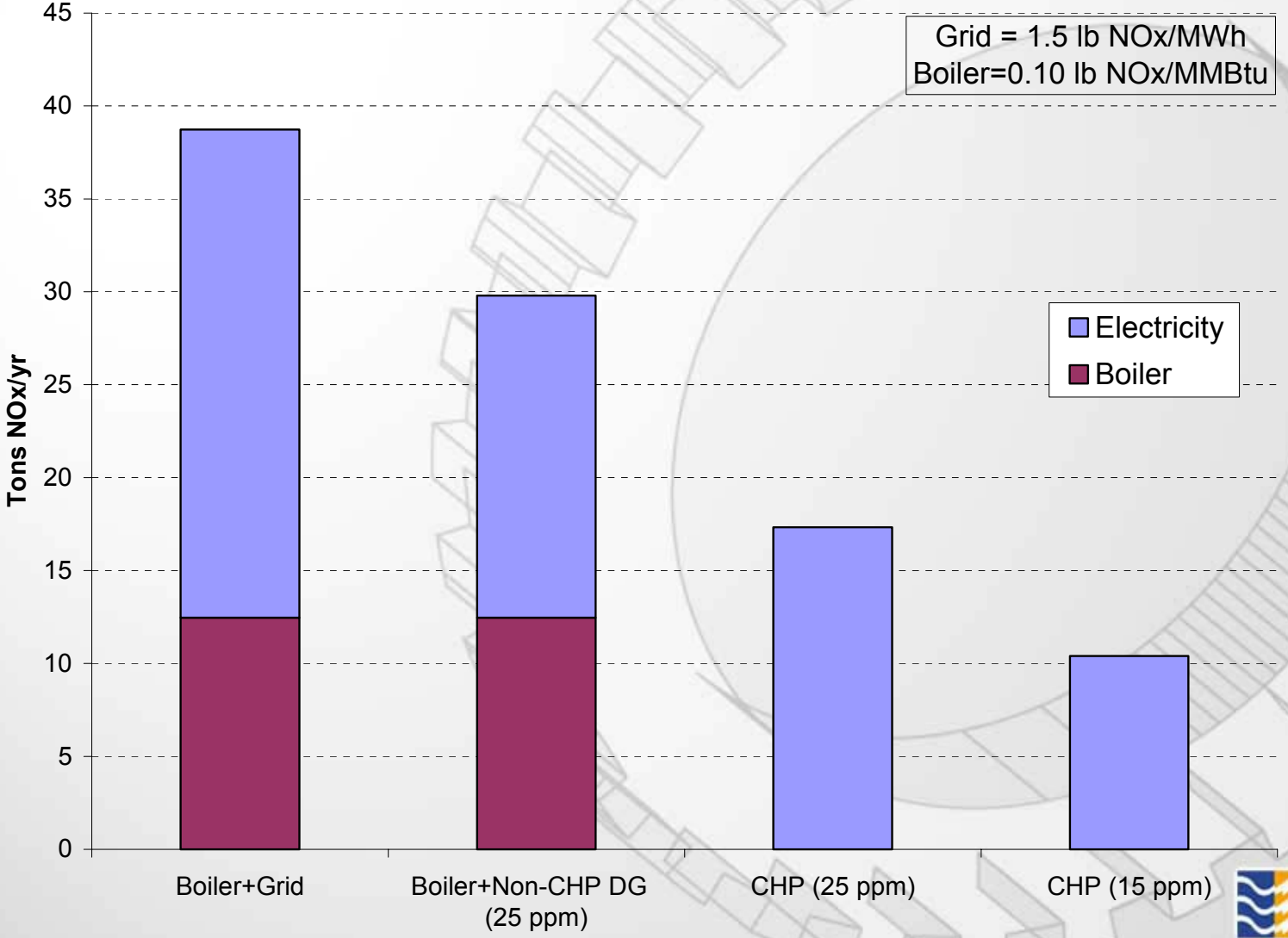
# Central Power vs On-Site CHP Emissions

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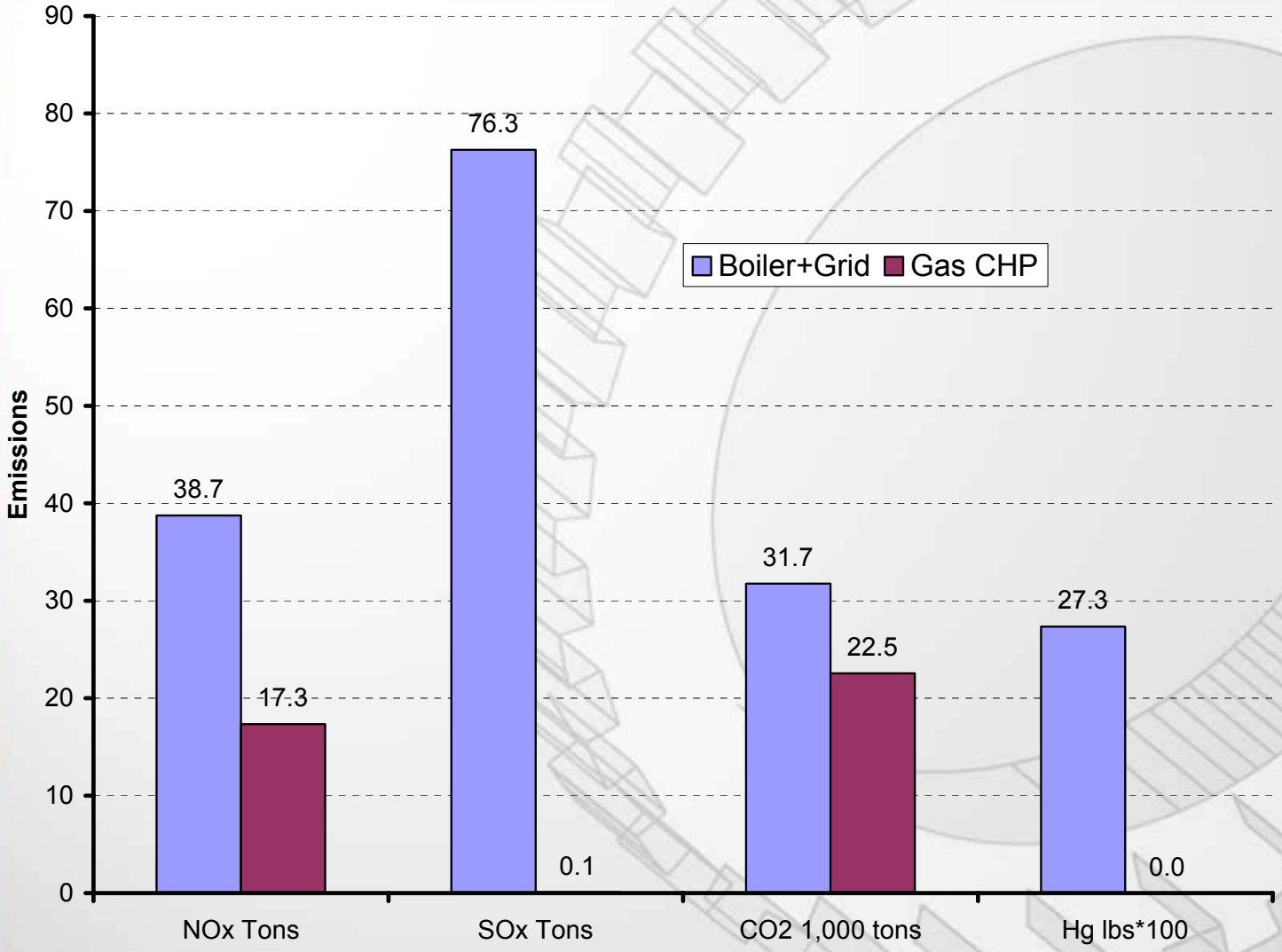
# Multipollutant CHP Benefits

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# Valuing CHP

- Conventional air regulation does not encourage CHP and can discourage it.
  - Promotes capital investment in tailpipe controls over new process technology.
- Output-based regulation is a key tool in recognizing and rewarding CHP.

# How to Implement Output-Based Regulation

- Development of output-based emission limits
- Use of gross vs net energy output
- Compliance measurement
- Treatment of CHP

# Development of Limits

- In the near term, we start with input-based limits and convert units to output format.
- Ideally, limits will be based on output-based measurements.
  - Output-based limits allow for uniform and direct comparisons.

# Input to Output Conversion

- Power generation - lb/MMBtu, ppm or g/bhp-hr to lb/MWh.
- Industrial boilers - lb/$MMBtu_{input}$ to lb/$MMBtu_{output}$.
- Requires unit conversions and efficiency factor.

# Net vs Gross Output

- Net output deducts internal loads and losses.
- Use of net is closer to policy goal of recognizing overall efficiency.
- Calculation of net can be complicated for large power plants.
- Tradeoff must be made between policy goal and complexity.

# Compliance Measurement

- Emission measurement is the same regardless of rule format.
- Output measurement may require new procedures but there are no fundamental barriers.
- Output is often measured as part of plant business (selling the product).

# Output Measurement

- Electricity output is easily measured and often measured for commercial purposes.
- Thermal output of large boilers is often measured for plant operation purposes.
- CHP facilities often measure thermal output for sales purposes.
- *The technology is available.*

# Accounting for Multiple Outputs

- CHP provides electric and thermal service with higher efficiency and lower emissions than conventional separate systems.
- Output-based regulation is key to recognizing efficiency benefits of CHP.
- Multiple outputs (heat and power) must be addressed.

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# Two Approaches for Calculation

- Add thermal output to electric output to reduce effective emission rate. (NSPS, CA, TX)
- Calculate credit for avoided thermal generator (boiler). (RAP Model Rule)
- First option is simpler. Second option more directly reflects actual emission benefits.

# Thermal Output Approach

- Set basic standard in lb/MWh.
- For CHP system, compliance is calculated as: emissions/($MWh_e$ + $MWh_{th}$)
- Some regulations allow only partial thermal credit.
- Impact is primarily a function of system design (P/H).

# Displaced Emission Approach

- Set basic standard in lb/MWh.
- For CHP system, compliance is calculated as:
  (emissions - avoided emissions)/$MWh_e$
- Avoided emissions are the emissions that would have been created by a boiler providing the same thermal output.
- Reflects actual environmental benefits.

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# Case Study - NSPS

- In 1998 EPA promulgated revised NSPS for electric utility boilers.
- Changed from input-based, fuel-specific standard to a uniform output-based limit in order to encourage efficiency/ consistency.
- Addressed issues of rule development, measurement and implementation

# NSPS Implementation

- lb/MWh measure to encompass total plant efficiency.
- Gross output to simplify measurement.
- Limit initially based on conversion of input-based data. Final value based on measured output-based data.
- CHP credit based on 50 percent thermal credit.

# Impacts of Output-Based NSPS

- Important indicator of EPA support for output-based regulation.
- Addressed many basic questions regarding output-based regulation, compliance measurement, treatment of CHP.
- Few if any new affected boilers built yet but the value for supporting other regulations has been great.

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# Case Study - National Model Emissions Rule for DG

- An output-based national model rule has been developed under DOE funding through a stakeholder process facilitated by the Regulatory Assistance Project.
- Draft rule available at: http://www.raponline.org

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# Model Rule

- Sets uniform output-based standards.
- Accounts for CHP output via displaced emissions.
- Encourages precertification.
- Three phases of progressively more stringent limits.

# Who Has Done Output-Based Regulation?

- Conventional rate limits
- Distributed generation
- Allowance allocation
- Multipollutant programs
- Generation performance standards

# Conventional Rate Limits

- EPA NSPS for utility boilers - uniform output-based limit with credit for CHP
- Ozone Transport Commission Model $NO_x$ Rule - sets $NO_x$ limits for combustion turbines in lb/MWh

# Distributed Generation

- California SB 1298 certification program and BACT guidance - output-based limits for $NO_x$, VOC, CO and PM with some credit for CHP.
- Texas general permit for DG - output-based $NO_x$ limits and full thermal credit for CHP.
- RAP Model Rule - Output-based limits for $NO_x$, CO, PM with emission credit for CHP.

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# Allowance Allocation

- Primarily for OTC and SIP call $NO_x$ trading programs.
- Output-based systems in:
  - Connecticut
  - Massachusetts
  - New Hampshire
  - New Jersey

# State Multipollutant Programs

- Output-based limits set for four pollutants in:
  - Massachusetts
  - New Hampshire

# Federal Multipollutant Programs

- Clear Skies Initiative - Output-based emission performance standard replacement for NSR.
- Carper bill - output-based allocation
- Jeffords bill - output-based set asides for renewables, CHP, efficiency

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# Generation Performance Standard

- Derives from Massachusetts restructuring language.
- Requires retail sellers to meet output-based portfolio emission standards including out of state generation.
- Connecticut and New Jersey have considered similar requirements.

# Next Steps

- Output-based regulation is the mechanism to encourage further efficiency improvements.
- We will do additional work to complete and distribute a draft report.
- Follow up with outreach and coordination to determine a Phase 2.

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